volume 20, June 2003

FAA Satellite Navigation Product Teams

SatNav News

LAAS Contract Award and Beyond

by Hazel Russell, GPS TAC/AND-710

The Federal Aviation Administration (FAA) moves forward with a satellite landing system to improve aircraft safety during airport approaches and landings. On April 30, 2003, the FAA awarded the Local Area Augmentation System (LAAS) Category I contract to Honeywell International, Inc. of Minneapolis, MN. LAAS is a satellite navigation landing system that enables pilots to guide planes safely into busy airports in bad weather. LAAS will significantly enhance the safety and efficiency of air travel by increasing the accuracy, availability, continuity and integrity of the information received from the Global Positioning System (GPS).

The contract, originally scheduled for an award last September, was restructured to minimize the FAA's financial exposure and reduce technical risks by separating the design and development phases. The current contract has three phases. Phase I, valued at $16.7 million, provides for the software and hardware design. Phase II and III, with values totaling $340 million, are contract options that cover the development and production of the system. If the Phase II option of the contract is exercised, the operational Low Rate Initial Production (LRIP) LAAS will be installed at airports in Juneau, Phoenix, Chicago, Memphis, Houston and Seattle. The first system is scheduled to be operational by late 2006.

Following the contract award, the LAAS team participated in the Post Award Conference that was held at Honeywell's facility in Minnesota on May 14-16, 2003. The Contractor presented its overall approach in meeting the Government's requirements and both sides had an opportunity to talk. The Conference was a success and both teams are currently looking forward to working together and providing LAAS to the National Airspace System (NAS). LAAS is expected to provide a significant improvement in aircraft and airport operations. LAAS Category I precision landing provides a level of service in poor weather conditions down to a ceiling of 200 ft. and visibility of one-half mile. LAAS can be installed at some airports where conventional landing systems can't be used because of space or radio frequency spectrum constraints.

In this issue:

A single LAAS will provide precision landing service for most runways at an airport and will transmit approaches to each equipped aircraft that would avoid obstacles, restricted airspace, noise sensitive areas, or congested airspace.

WAAS International Expansion

Ed Sigler, GPS TAC/AND-730

The FAA's Wide Area Augmentation System (WAAS), once commissioned into the National Airspace System this year, is designed to provide position correction and integrity information to aviation and non-aviation users. The WAAS will provide service across the United States using a series of reference station (WRS) sites. WAAS interest is generating from outside the U.S. due to the success of the WAAS program, coupled with the International Civil Aviation Organization (ICAO)'s desire to implement Satellite Based Augmentation Systems (SBAS) across the world.

The FAA will authorize the use of WAAS only within the National Airspace System (NAS). However, the WAAS is capable of providing service sufficient for LNAV/VNAV and LPV approaches across large portions of Canada and Mexico with the addition of minimal reference stations in those countries. Recently, the FAA began dialogue with officials from Navigation Canada and SENEAM of Mexico to locate additional WRS sites in these countries.

WAAS Program Manager Dan Hanlon, WAAS Technical Manager Leo Eldredge, and WAAS System Engineer Jeff Auerbach, met with Canadian Officials in April 2003. The FAA and Canadian officials drafted an agreement calling for the placement of up to four WRS sites within Canada, which would expand WAAS service across most of Canada. By adding WRS sites in Canada, the FAA also improves WAAS coverage and service levels across the northern U.S., particularly in New England.

Dan Hanlon, and technical and international representatives from FAA Amy Johns, Dave Burkholder and Carey Fagan, met with Mexican officials from SENEAM in Mexico City on April 3, 2003. During these discussions, the FAA and SENEAM arrived at a tentative relationship for the placement of five WRS sites within Mexico, expanding WAAS coverage across nearly all of Mexico. Doing so would improve the FAA's WAAS coverage and service levels within the U.S. along the southwestern border. WAAS service extension to Mexico and Canada is expected to be complete by 2005.

FAA representatives Dan Salvano and Dan Hanlon, met with Brazilian officials in April 2003. As most of Brazil and South America receive the WAAS signals via Geostationary satellites, the information contained in these messages does not provide for position corrections in these locations. Although it is possible to modify the existing WAAS system to provide correction information for South America, the complexity and cost are prohibitive. With the assistance of the FAA, the Brazilian government intends to install reference stations and processing centers, based on WAAS technology, to provide SBAS service across Brazil and other South American countries. The WAAS-based South American SBAS system is expected to be operational within the next few years.

LAAS -The Next Step

by Cedric D. Lewis, GPS TAC/AND-710

The FAA awarded a contract for the Category I Local Area Augmentation System (LAAS) to Honeywell International Inc. of Minneapolis, MN on April 30, 2003. The contract provides for 10 Limited Rate Initial Production (LRIP) systems beginning in 2006. Four of the systems will be used for test and evaluation, and training. The remaining six will be

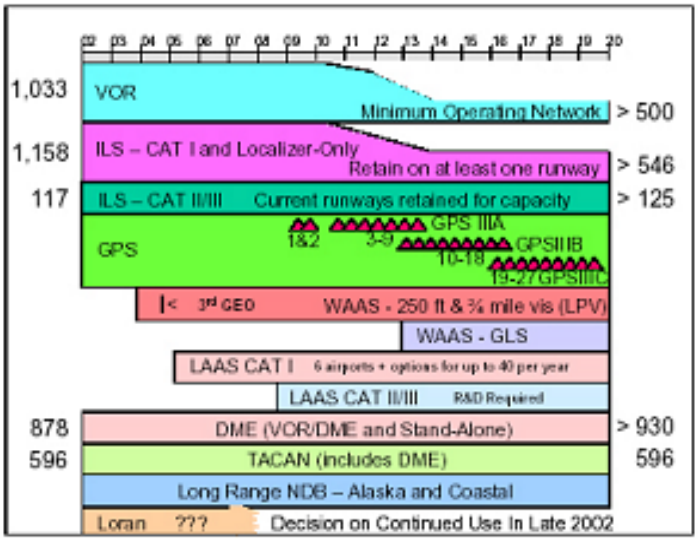
installed at major commercial airports, each with a single LAAS providing approach guidance for multiple runway ends. Air-carriers will use the six systems to assess operational benefits while in daily revenue service.

The FAA plans to spend hundreds of millions of dollars to replace the aging National Airspace System (NAS) infrastructure but it will be all for naught if the air-carriers do not utilize the system. At the same time, the operators want to make sure that there is an economic pay off for them before they commit to equipping their aircraft. The air-carriers need to establish and validate a business case by comparing the cost of the aircraft receiver equipage and training with the economic benefits of increased efficiency and fuel savings.

The FAA is working with "IBM Global Services" (formerly Price Waterhouse Cooper) on a "LAAS Benefit Assessment". The IBM assessment will include maximum sponsor and stakeholder involvement. The assessment is in collaboration with the Investment Analysis and Operational Research branch (ASD-400) and the Regulation and Certification Group (AVR). The LAAS benefit assessment results combined with the operational results, will assist the FAA in making a decision to move forward with acquiring additional LAAS systems.

The activities associated with the development of Catagory I LAAS are viewed as a "stepping-stone" to Category III. This is especially true for integrity validation. Experience gained from WAAS shows that the most challenging requirement for GPS augmentation is integrity. Integrity is the assurance that there are only rare occurrences when aircraft receive any hazardously misleading information (HMI). It is specified as a probability of 2x10-7 and 10-9 per approach for Category I and Category III respectively. The other navigation parameters, availability, continuity, and accuracy, are equally as important but deemed easier to achieve. The FAA is continuing with Research and Development (R&D) activities on Category III LAAS to define high-level system performance requirements and to mitigate critical technical risk areas. Standards are being developed through the Radio Technical Commission for Aeronautics (RTCA) and the International Civil Aviation Organization (ICAO) processes. Based on results of the Category II/III R&D efforts, and the LAAS Benefit assessment, the FAA will make a decision in 2005 on the feasibility of pursuing a Category 3, full-scale development and production contract.

In Summary, GPS is a quantum leap in aviation technology, which is being exploited to improve safety and efficiency. The business cases for both the LAAS users and the FAA are being structured. Category I LAAS is now under contract and



will soon be a reality. Research and development on Category II/III is moving the technology ahead as the FAA continues to refine and validate the requirements. The full economic benefits for the FAA will come when the FAA eliminates some of the ground-based navigation aids (navaids). For the foreseeable future, however, a significant number of navaids will be retained to provide a robust and redundant navigational capability.

FAA Alaska Capstone Program

by Don Streeter, FAA AFS-400

The Alaskan Region's Capstone Program is an accelerated effort to improve aviation safety and efficiency through installation of government-furnished Global Positioning System (GPS)-based avionics and data link communications suites in commercial aircraft. Compatible ground systems, equipment, and services will also be provided.

At the recent Joint Aviation Authority (JAA)/FAA Annual Conference's Communication Navigation Surveillance (CNS)/ Air Traffic Management (ATM) Workshop, the Capstone project was used as an example of the real-time

implementation of new technologies in CNS/ATM; and the demonstration of benefits achievable through its implementation. The JAA noted in the out briefing, that while work traditionally focused on CNS, today's economic environment requires evaluation of the ATM element and how CNS technologies benefit ATM.

The Alaska Capstone Program's primary purpose is to decrease the number of aircraft accidents in Alaska. Data from a current Capstone Safety Study indicates that the Capstone Program is reducing accidents and fatalities in Alaska while providing an implementation path for advanced CNS/ATM capabilities in the National Airspace System. The advanced capabilities will move us closer to "Free Flight" and resulting safety, efficiency, and capacity benefits.

Some of the successes from the Capstone program include:

- On April 4, 2000, Capstone-equipped aircraft were authorized to use Automatic Dependent Surveillance Broadcast (ADS-B) for "enhanced see and avoid" using a cockpit display of traffic information.

- On January 1, 2001, the Capstone Program efforts resulted in the Anchorage Center providing "radar-like" services for surveillance of ADS-B equipped aircraft in non-radar airspace in Alaska.

- On March 13, 2003, FAA Administrator Marion Blakey approved special Federal Aviation Regulation (SFAR) No. 97. This special "Alaska" rule authorizes properly trained pilots using Technical Standard Order C145a/C146a GPS and Wide Area Augmentation System (WAAS) navigation systems to fly on air traffic routes at special (lower than usual) GPS Area Navigation (RNAV) altitudes using certified and approved GPS/WAAS avionics for navigation. Initial application of SFAR No. 97 in Southeast Alaska has already created 41,000 feet of usable airspace spread over 1,521 nautical miles of existing routes.

- On March 26, 2003, the FAA established guidance and requirements for the operational approval and use of GPS/WAAS RNAV systems as the only means of navigation in Alaska airspace.

- On March 26, 2003, the Anchorage FAA Aircraft Certification Office issued a Supplemental Type Certificate (STC) to Chelton Flight Systems Inc., certifying the Chelton Flight Systems FlightLogic electronic flight information systems (EFIS) equipment to TSO C146a Class Gamma 1. This system complies with FAA Advisory Circular 20-138a for navigation using GPS and WAAS for en route, terminal area, and non-precision approach operations (including "GPS" or "GPS and RNAV" approaches). The installed system includes: an Integrated Display Unit that can be configured as a Primary Flight Display or a Multi-Function Display, up to two Air Data Computers, up to two GPS receivers, up to two Attitude and Heading Reference System units, and an Analog Interface Unit with reversionary switching as needed.

- On March 31, 2003, L.A.B. Flying Service, the first certified air carrier operator based in Juneau, AK authorized by the FAA to conduct instrument flight rules (IFR) RNAV operations using Capstone Phase II EFIS avionics, departed from Juneau in a Piper Seneca PA-34-200T on a round trip to Sitka on V431 at 6,000 feet ending with the approach to Sitka Runway 11. The aircraft returned to Juneau via V428 at 6,000 feet with an approach and landing at Juneau using the Runway 8 localizer type directional aid (LDA) approach. This IFR RNAV flight was conducted under the authorization specified in SFAR No. 97 using certified GPS/WAAS systems as the only means of en route navigation outside the operational service volume of ground-based navigation aids.

Phase I of the Capstone Program resulted in the installation of IFR certified GPS navigation systems, multi-function displays that provide navigation, traffic, terrain, and weather information, and data link communications capabilities. The capabilities resulted in the first ever "radar-like" air traffic services using automatic dependent surveillance-broadcast [ADS-B] in Alaskan airspace on January 1, 2001.

Capstone Phase I Apollo MX-20 is a 6" Diagonal, color, Multi-function cockpit display in the custom map mode.

Capstone Phase I GX60 is a TSO C129(A1) certified GPS navigation and communication solution in a single two-inch package

Capstone Phase I Universal Access Transceiver (UAT) and antenna is a radio datalink system supporting Automatic Dependent Surveillance Broadcast (ADS-B), Traffic Information Service (TIS-B) and Flight Information Service (FIS-B).

Capstone Phase I resulted in the equipage of approximately 180 aircraft conducting scheduled and on-demand air carrier operations in the Bethel and the Yukon-Kuskokwim Delta area in western Alaska.

Capstone Phase II will equip approximately 200 aircraft [including 50 helicopters] with Capstone Phase II equipment in southeast Alaska. Capstone Phase II also provides for implementation of an IFR RNAV infrastructure in southeast Alaska using advanced navigation, communication, and surveillance technologies and applications.

Capstone Phase II Chelton PFD and Navigation Display installed in a Single Engine Cessna 172RG

The Capstone program is a dynamic program that includes dedicated FAA and aviation professionals who are not only working in partnership to develop criteria and requirements for implementation of advanced CNS/ATM technology, but are also working with appropriate FAA procedures, air traffic,

Chelton PFD and Navigation Display in twin enginePiper Seneca [PA-34-200T]

airways facilities, flight standards, aircraft certification, and other lines of business to ensure that an IFR infrastructure is in place to support the technology. The successes of the FAA Alaska Program have become a catalyst for implementation of advanced CNS/ATM technology in the National Airspace System and throughout the world.

For additional information regarding the FAA Alaska

Capstone Program and associated technology the following Internet web site should be helpful (www.alaska.faa.gov/capstone).

For additional information or questions regarding this article, please contact Don Streeter, FAA Flight Technologies and Procedures Division (AFS-400), (202) 385-4567 or on email at donald.w.streeter@faa.gov.

WAAS Helping To Solve Worldwide Agricultural Problems

by Eric Fly, GPS TAC

The worldwide agricultural community faces three great challenges: how to feed an ever-increasing world population, increase on-farm profits so farmers can keep their land, and decrease the impact that modern agriculture can have on the environment. To assist farmers in accomplishing these tasks, an unlikely alliance has taken place.

The FAA has become a welcome partner in helping the agricultural industry meet and solve its challenges. FAA's Wide Area Augmentation System (WAAS), once considered just an aviation tool, is becoming the very foundation for much of the new technology being employed by the agricultural community today. Thanks to the FAA's implementation of the WAAS, agriculture has a powerful new Differential Global Positioning System (DGPS) tool.

Before anyone in agriculture had heard of WAAS, the agricultural community was well on its way to creating new tools and techniques to solve the problems facing a growing world. These new agricultural tools range from new soil sampling techniques, to yield monitors for combines, to variable rate applicators for the accurate placement of fertilizer, chemicals and seeds and many other new and exciting tools and techniques.

Each of these new tools holds the hope and promise that agriculture could continue to feed a growing world using fewer acres, while creating a cleaner environment. However, the agriculture industry realized that many of these new tools and techniques require accurate, reliable DGPS to provide repeatable field location. Furthermore, DGPS was an area of new technology that only a few in the agriculture community were comfortable with. The agricultural industry also realized that the need for DGPS and its receiver in many cases doubled the cost of this new equipment preventing many farmers from adapting these tools and techniques.

Due to the prohibitive cost of these promising new tools from 1995 to 2000, they remained virtually unused. During this time, many agricultural technology companies went out of business waiting for the farm economy to embrace these new technologies. Over this five-year period, the agriculture community tried using the USCG Beacon system and real-time kinematic (RTK) base stations with little success. The only reliable DGPS that was available during this time was OmniStar's L-Band signal, which helped to sustain what is now known as the precision agriculture industry. OmniStar also played a vital role in introducing and educating the agriculture industry to the world of satellite navigation. The long awaited breakthrough came in 2000, when Northstar Technologies of Acton, MA introduced the agricultural industry to the world of WAAS.

At last, the manufacturers and farmers involved in this new precision agriculture industry saw an opportunity to greatly reduce the cost of precision agriculture equipment by incorporating the new WAAS technology into their products. Almost at once, the agriculture industry showed the value that the WAAS would bring to precision agriculture. A recent study conducted by Dr. Jay T. Akridge of Purdue University shows that in 2001, only 7.1 percent of United States farmers were using yield monitors on combines compared to 17.2 percent in 2002.

Studies conducted by TVC, a Virginia based agricultural consulting firm, shows that the use of WAAS was and continues to be a major contributing factor in this increase use of precision agriculture. TVC studies also show that around 20.5 percent of farmers in the United States are now involved with precision agriculture and that over 230,000 farmers involved in precision agriculture are reaping the benefits of WAAS. One day, the number of WAAS users in agriculture will out number those found in the aviation community. Today, every major company that manufactures precision agriculture equipment offers WAAS as a DGPS option. Many companies are offering WAAS only receivers as standard equipment.

Through the use of precision agriculture, farmers are reporting yield increases from three percent to five percent in major crops, such as corn, wheat and soybean helping to feed a growing world. Studies conducted by Agco Corporation and Silso Research Institute in the U.K. have shown the ability to decrease nitrogen use in wheat as much as 33 percent by using precision agriculture, thereby helping farmers protect the environment. U.S. farmers are showing net gains in on-farm profits as much as $10 an acre by using these new tools and technologies. Unlike five years ago, the precision agriculture industry is spreading around the world. Much of this success can be contributed to the FAA's implementation of WAAS.

The agricultural industries in countries such as Argentina, Brazil, Chile, Peru, Australia, the U.K., and Demark also seek to use WAAS to bring about similar results. TVC estimated that the value WAAS will bring to the U.S. agriculture community may reach well over $400 million in the next three years. WAAS is truly becoming a worldwide agricultural utility.

LAAS Operational Applications Implementation On Track

by Tracey Golden, GPS TAC/AND-720

The Local Area Augmentation System (LAAS) implementation remains on schedule with the continued meetings of the Satellite Navigation User's Group (SNUG) at airports selected to receive initial Low Rate Initial Production (LRIP) systems. Four of the six airport locations in Chicago, IL, Juneau, AK, Memphis, TN, and Phoenix, AZ have held at least two meetings. The remaining sites in Houston, TX and Seattle, WA have meetings planned in the coming months. The meetings are designed to focus on identifying specific operational applications that can meet the unique terminal area demands of each airport and establish operational test beds for the deployment of future systems.

In April 2003, America West Airlines hosted SNUG meetings for LAAS implementation at Phoenix Sky Harbor International Airport. The high interest level was indicated by the attendance of a broad cross section of airlines, manufacturers, airports, FAA Regional personnel, and air traffic controllers and by the extensive number of questions. Users were primarily concerned with issues pertaining to required navigation performance (RNP), avionics, and piloting. Some of the issues included:

Display Requirements/Annunciations
Identification of LAAS Equipped Aircraft
Aircraft System Interface Activities
Controller/Pilot Training
Pilot Flight Technical Error (FTE)
RF Leg Implementation and Certification

Because of the significant air traffic generated by corporate and business jet activity, there is heavy interest for precision service at satellite airports. The desire for LAAS capability to improve minima at adjacent airports is directly aligned with the desire to create useful operational test beds. The FAA is seeking a lead organization to help develop a linking study for remote broadcast to the Scottsdale airport from the Sky Harbor location. Airlines expressed a need for a set of precision approaches that will improve noise reduction and lower minima that ILS will be unable to deliver upon completion of the new Phoenix control tower. In addition, precision guided departures and missed approaches complete a suite of precision tools that will make efficient and safe use of shrinking terminal airspace.

✔ LAAS operational applications will develop slowly in Phoenix. Terminal area users favor an incremental approach beginning with the conversion of existing operational tracks to LAAS guided applications. Current requirements to meet that desire include:
✔ LAAS straight-ins at Sky Harbor requested by airlines.
✔ Cleaner (tighter RNP) arrivals and departures and guided missed approaches.
✔ Applications that provide improved satellite airport service and minima at Scottsdale (SDL), Goodyear (GYR), and Deer Valley (DVT).

The meetings in Phoenix are representative of meetings held at all airport sites selected as LAAS test beds. Although each

airport has a unique operational environment, users express similar concerns. Each site will find its own remedy and method of employment for LAAS. For the remainder of fiscal year 2003, AND-720 will be gathering information at each site for LAAS Prototyping in hopes that they will all prove LAAS' ability to provide repeatable, reliable, and accurate terminal routing that enhances capacity, efficiency, safety, and savings throughout the aviation industry.

Geostationary Communications and Control Segment (GCCS)

by Bill Tisdale GPS TAC/AND-730

The FAA's Wide Area Augmentation System (WAAS) consists of space and terrestrial components that, once used with WAAS certified avionics equipment, will provide major improvements in the accuracy, reliability and safety of the Global Positioning System (GPS). WAAS supports air navigation for all phases of flight in the National Airspace System from departure through en route and non-precision approaches.

The Geostationary Communications and Control Segment (GCCS) is a key subsystem of the WAAS. The basic GCCS element consists of a special navigation payload carried on a commercial communications satellite, served by a dedicated pair of geographically separated ground uplink stations (GUSs). The FAA is actively planning to procure GCCS services from two satellites and four GUSs. The terms of the GCCS contract provide the option for service from a total of three satellites.

The primary mission of the GCCS is to provide highly reliable signals-in-space (SIS) that are similar, but not identical to, the existing GPS signals. One signal will broadcast on the standard GPS L1 frequency, and the other on a new frequency identified as L5. The GCCS SIS will include information in compliance with GPS standards used to calculate a receiver's three-dimensional position and the exact time. In addition, the GCCS SIS will incorporate information provided by the WAAS that can be used to establish the integrity of the SIS itself, and to facilitate corrections to the receiver's calculated position.

GCCS services will be provided entirely through a long-term lease arrangement with prime contractor Lockheed Martin Air Traffic Management (LMATM). The Government will fund design and development activities, but will not procure or own the equipment. A letter contract to initiate the development and satellite payload efforts was issued to LMATM, on March 4, 2003. Members of LMATM's team include the Raytheon Co., The Boeing Company, and NovAtel Inc.

Selection of two initial providers for geo satellites and payloads is well under way. The initial Program Management review and the Systems Requirements Review were held June 4 - 5, 2003. The Preliminary Design Review is scheduled for August 2003. GCCS factory integration and test is planned for May 2005. This will be followed by field tests, and subsequent integration into the WAAS.

WAAS Receivers

by Bob Beal, GPS TAC/AND-720

WAAS Procedures

In a previous SatNav News article *(SatNav News, Volume 19, April 2003, p.7)*, I wrote about the first Wide Area Augmentation System (WAAS) receivers to be certified for aviation use and discussed the various WAAS receiver operational and functional classes.I described the WAAS receiver Gamma, Beta, and Delta functional classes in conjunction with (1) the related operational classes and (2) the technical standard orders under which WAAS receivers are certified. Since some of that jargon may be a little arcane for many readers. The following presents a more practical description of the receiver operational capabilities and why it may be important to understand these capabilities when selecting a WAAS receiver. This article addresses the various approach classes, elaborates on the UPSAT and Chelton receivers, and provides some insight into the plans of some of the other potential WAAS receiver manufacturers.

Not all WAAS receivers are created equal. Whereas Beta, Gamma, and Delta are terms that describe receiver configurations, the operational classes determine the operations those receivers are certified to perform. Receivers that use just the Global Positioning System (GPS) without WAAS augmentations can be used to fly procedures that do not require vertical guidance. WAAS enables GPS to be used for vertical guid-

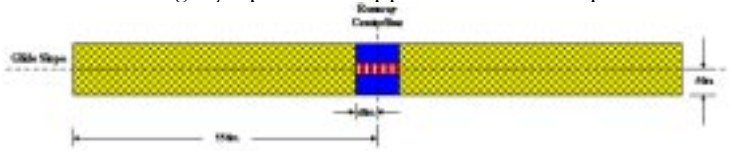
ance with added safety improvements. In the United States there are basically three types of vertically guided approaches; Lateral Navigation with Vertical Guidance (LNAV/VNAV), Localizer Precision with Vertical Guidance (LPV), and Precision (Category I, II, and III).

When WAAS is commissioned, it will support LNAV/VNAV and LPV approach procedures. In fact, LPV is a new procedure type being introduced into the National Airspace System along with the introduction of WAAS. Not only will new LPV procedures be developed, but virtually all of the existing GPS-RNAV procedures will be upgraded to include LPV approach minimums. WAAS will ultimately be able to support Category I precision approaches once the second civil broadcast frequency is added to the GPS constellation.

How do the different procedure types and WAAS operational classes relate? Figure 1 represents a vertical slice through these three approach types viewed as if a pilot was flying into the page. The yellow (cross-hatched) rectangle is the area that needs to be protected for an LNAV/VNAV approach, the blue (solid) for an LPV approach, and the red (vertical stripes) for a Category I precision approach..

Because of navigation system accuracy and integrity, for an LNAV/VNAV approach, the procedure designer has to protect an area (at the missed approach point) that is ±556 meters in the horizontal direction (either side of centerline) and ±50 meters in the vertical direction. Stated another way, the horizontal and vertical alert limits for an LNAV/VNAV approach are 556 meters and 50 meters respectively (yellow area). For an LPV procedure, the limits are ±40 meters in the horizontal and ±50 meters in the vertical (blue area), and ±40 meters in the horizontal and ±12 meters in the vertical for a Category I precision approach (red area).

Figure 1 shows that a much greater area must be protected for an LNAV/VNAV procedure than for an LPV procedure; likewise a larger area must be protected for an LPV procedure than for a Category I precision approach. An LPV procedure



WAAS Approach Type Comparison
Figure 1

combines LNAV/VNAV vertical accuracy with precision approach horizontal accuracy requirements thereby greatly reducing the horizontal footprint of the LPV approach compared to an LNAV/VNAV approach. This can substantially reduce the number of obstacles that can interfere with the approach procedure (i.e., penetrate the obstacle clearance surfaces) and typically results in lower approach minimums for LPV procedures (as low as 250 feet).

Because LPV procedures are so similar to Category I precision approach procedures, they use precision approach obstacle clearance criteria. As a result, a receiver certified to fly an LPV approach procedure must meet the same criteria as a receiver certified to fly a precision approach procedure. These criteria are more stringent than the criteria for LNAV/VNAV procedures (e.g., higher navigation solution update rates, higher software integrity requirements, greater database integrity requirements, etc.). GPS receivers are built to less stringent standards than WAAS receivers; therefore GPS receivers that are upgraded to meet WAAS certification requirements will typically be certified for LNAV/VNAV only. To achieve LPV certification requires significant improvements that are very difficult to meet through a GPS upgrade. Now let's look at what the various general aviation avionics manufacturers are doing.

WAAS Receiver Status

UPSAT was the first company to certify a WAAS receiver. The UPSAT Apollo CNX80 is a new production receiver that can meet all of the requirements needed for LPV certification, including a 5 Hz navigation solution update rate. As shown in Figure 2, the CNX80 integrates GPS/WAAS with a moving

UPSAT Apollo CNX80 WAAS Receiver
Figure 2

map, VHF communications, VHF Omnidirectional Range

(VOR) navigation, and Instrument Landing System (ILS) localizer and glide slope receivers. The CNX80 supports direct routing, jet and victor airways, standard instrument approach procedures, curved-path navigation, holding patterns, procedures turns, and standard instrument arrival and departure procedures.

Chelton Flight Systems uses FreeFlight Systems' GPS/WAAS receiver in its synthetic vision Electronic Flight Information System (EFIS). This GPS/WAAS receiver is a sensor only that provides current position, velocity, and time information to the Chelton EFIS. The EFIS provides the procedure database, navigation function, and pilot interface. As shown in Figure 3, the Chelton EFIS incorporates Highway-in-the-Sky (HITS) technology a series of 3-dimensional boxes along the flight path that provide added pilot situational awareness. The Chelton EFIS is the first navigation system to receive HITS certification. The primary EFIS flight display combines pitot-static information from an air data computer, attitude and heading information from a solid-state 3-axis gyro, and position information from the WAAS sensor.

Chelton Fight Systems' Synthetic Vision Electronic Flight Information System
Figure 3

The Chelton EFIS was developed in conjunction with the FAA's Alaska Region under Phase II of its Capstone Program. The goal of the Capstone program is to improve aviation safety and efficiency through installation of next-generation government-furnished GPS-based avionics and data link communications suites in most commercial aircraft serving the southeastern Alaska region.

As noted, FreeFlight Systems developed the certified WAAS sensor used in Chelton's EFIS. This sensor was certified for LNAV-only. FreeFlight Systems plans to upgrade that sensor to support LNAV/VNAV in late 2003 and to support LPV in mid-2004. FreeFlight Systems also plans to offer a new WAAS receiver that will support LPV, as well as an LNAV/VNAV upgrade, to their existing 2101-series panel-mount GPS receiver. Garmin plans to provide a WAAS upgrade to their 430/530-eries GPS receivers in late 2004, but has no near-term plans to produce a new WAAS receiver. As noted above, as a GPS upgrade, Garmin's WAAS receivers will probably not support LPV without an associated hardware modification to meet the 5 Hz navigation solution update rate required for LPV. Bendix-King, unlike Garmin, plans to introduce WAAS as a new product rather than as an upgrade to their current line of GPS receivers. A Bendix-King WAAS receiver is expected in late 2004 and should support all WAAS procedure types. Bendix-King has not ruled out an upgrade to their current GPS products.

Conclusion

Unlike most previous navigation systems, not all WAAS receivers are certified to perform the same operational procedures. Depending on the level of certification, some WAAS receivers may only be able to perform those operations (e.g., LNAV) already supported by GPS-alone, albeit with improved integrity and accuracy. Some will support LNAV/VNAV-only, and others will support LNAV/VNAV and LPV. The user should be aware of these differences, determine the needed level of performance, and then decide which receiver best meets those needs. When buying a receiver it is important to understand what you are buying. The information presented in this article is always subject to change as the manufacturers reassess the marketplace and their business plans. Much of this information was obtained on the web, while other information was obtained directly from the vendors at air shows and other venues.

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